Order of horse - perissodactyla

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EVOLUTION

* Evolutionary Biology – study of history of life forms on earth.
* Changes in → flora, fauna → occured → over millions of years on earth.
* Story of ① origin of life ② evolution of life forms/biodiversity on earth → in context of → evolution of earth; against the → background of evolution of universe itself

ORIGIN OF LIFE

When we look at stars → we look back at time (took millions of yrs to come)

Stellar distances are measured in → Light years

* Universe → Vast Earth → speck
  - very old
  - → 20 billion yrs old.
  - → comprised of – Huge clusters of Galaxies contain → Stars, Clouds of ① gas ② dust.

Big Bang Theory attempts to explain → Origin of Universe

→ singular huge explosion (unimaginable in physical terms)

↓

Universe expanded

↓

Temp. ↓↓

↓

① H_2, ② He formed sometime later

↓

Gases condensed under gravitation

↓

Formed Galaxies of present day universe

Milky Way Galaxy – formed 4.5 billion yrs back.

* On early earth — no atmosphere

* Molten mass that covered earth → released → H_2O vapour, CH_4, CO_2, NH_3

* UV rays (from sun) → broke → H_2O → into → H_2 + O_2
  - H_2 → lighter H_2 escaped
  - O_2 → combined with ① NH_3 & ② CH_4 → they form → CO_2, H_2O (water), others
  - ★ Ozone layer was formed ★

* As it cooled (atmosphere) → Water vapour → fell as → Rain → to fill → depressions → forms → Ocean.

★

* Life appeared → 500 million yrs → after → formation of earth
  - i.e 4 billion yrs back
  - earth formed 4.5 billion yrs back

* Some scientists believed → Life came from outside

* Early Greek thinkers → thought → Units of life – spores → transferred to → different planets (including earth)

PANSPERMIA → still → favourite idea of some astronomers

* For a long time considered → Life came from → decaying rotting → straw, mud.

→ THEORY OF SPONTANEOUS GENERATION

* LOUIS PASTEUR → dismissed
  - Careful Experiments — demonstrated LIFE comes from PRE-EXISTING LIFE
  - In pre sterilised flasks → life did not come from killed yeast
  - Didn't answer — how first life forms came on earth!

Terrupoos - Bat.

Archaeonyx ...

Oparin from → Russia
Haldane from → England
proposed that → First life forms could have come from.
Pre-existing non living Organic molecules
① RNA ② protein

said
Formation of life was preceded
↓ by
chemical evolution
(i.e. formation of diverse organic molecules
↓ from
inorganic constituents)

* Conditions on earth were → high temp
→ Volcanic storms
→ Reducing Atmosphere
having
CH_4 NH_3

* 1953, S.L Miller (American scientist) created → Same conditions in Laboratory scale

created → Electric Discharge in a closed flask
contain → CH_4, H_2, NH_3
-ing
at 800°C
Water vapours

2 : 2 : 1
CH_4 : H_2 : NH_3

→ Observed : Formation of amino acids → glycine, alanine, aspartic acid

* In similar experiments, others observed → Formation of
sugars, Nitrogenous base, Fats, Pigments

* Analysis of Meteorite Content → also revealed → similar comp.
indicating → Similar process occurring else where in space

* With this limited Evidence — Chemical Evolution accepted
* No idea — how self replicating metabolic capsides of life arose

* Ist NON-CELLULAR life forms origin → 3 billion yrs back

They would have been Giant Molecules → RNA, protein, polysaccride

These capsules → reproduced their molecules perhaps

* Ist CELLULAR life forms origin → 2 billion yrs back (2000 million)

probably — single-cells

* All life forms were in → Water environment only

This Version of BIOGENESIS i.e first form of life arose slowly through evolutionary forces from Non-living molecules

accepted by majority !!

EVOLUTION OF LIFE FORMS - THEORY

* Conventional Religious Literature tells → THEORY OF SPECIAL CREATION

3 connotation

- Living organisms (species/types) that we see created as such.
- Diversity was always the same since Creation & will be same in Future
- Earth is 4000 yrs old.

strongly challenged in 19th century.

Charles Darwin → Sea Voyage
→ Sail ship — HMS Beagle
→ round the world.

concluded.

Existing living forms
share → similarities → to varying degrees
not only among themselves but also with life forms that existed million of yrs ago.

→ Many such life forms do not exist anymore.
There had been extinctions of different life forms
Years gone by
New life forms arose at different periods of history
Gradual Evolution of earth

* Any population has "built-in variations" in characteristics
these characteristics enable some to survive better in natural conditions
→ climate, food, physical factors
would outbreed others that are less endowed
to survive in such natural conditions

* FITNESS OF THE INDIVIDUAL/POPULATION — acc^n to Darwin refers ultimately & only Reproductive Fitness
Hence those better fit in an environment leave more progeny than others.
→ These, therefore will survive more & selected by the nature.
Darwin called it NATURAL SELECTION implied Mechanism of Evolution.

ALFRED WALLACE — A naturalist
→ Worked in — Malay Archipelago
→ had some similar conclusions as Darwin.
→ His theory :

* In due course of time, apparently new organisms are created
* All existing life forms, share → similarities
→ common ancestors

* These ancestors, were present at different periodes in history → epochs, period, eras

ERPEE PA

ERA ⟶ PERIOD ⟶ EPOCHS ⟶ AGE

* Geological history of earth —closely correlates with→ Biological history of earth

* Common permisable conclusion ⟶ Earth is very old (not thousands) but billions of yrs old.

WHAT ARE EVIDENCES FOR EVOLUTION?

(1) **FOSSILS** → Remains of hard parts of life forms
→ Found in — Rocks. ← forms — sediments

* Cross section of Earth's crust —indicate→ Arrangement of sediments one over the other. —during→ Long history of earth

* Different-aged rocky sediments —contain→ fossils of different life forms ↓ who probably died during formation of the particular sediment

Some of them → Appear similar to modern organism

→ Figure represents extinct dinosaurs

* A study of fossils in different Sedimentary layers —indicate→ Geological period in which they existed

udy showed — ★ Life forms varied over time
★ Certain life forms - restricted to certain Geological time spans.

→ Hence, New life forms have arisen at ★ different times in history of Earth

ALL THIS IS — PALEONTOLOGICAL EVIDENCE

(2) EMBRYOLOGICAL SUPPORT FOR EVALUATION

→ Proposed by — Ernest Hecket.
→ Based on — Observation of certain features during embryonic stage common to all vertebrates that are absent in adults.

Eg → Embryos of all vertebrates including human
head ← just behind ← A row of vestigial gill slits ← develop
but → It is functional in → Fish & not found in any other adult vertebrate

→ Disapproved by — KARL ERNST VON BAER
↓ noted
Embryos never pass through adult stages of other animals.

(3) Comparitive ANATOMY & MORPHOLOGY show similarities / differences among organism of today & those that existed yrs ago.

→ Such similarities can be interpreted to understand whether common ancestors were shared or not.

DIVERGENT EVOL.	CONVERGENT EVOL.
Structures are - Homologous	Structures are — Analogous
Homology indicates common ancestory	

① Whales, Bats, Cheetah, Humans (All mammals)

Share similarities in the patterns of bones of Forelimbs

These forelimbs perform different functions in these animals

Hey have similar anatomical struct.

all of them have

① Humerus ② Radius ③ Ulna ④ Carpals ⑤ Metacarpals ⑥ Phalanges in their forelimbs

* Hence, in these animals
same structure
developed along different directions
due to
adaptations to different needs

② Vertebrate hearts or Brains

③ In plants,
thorns — Bougainvillea
tendril — Cucurbita

① Wings of Butterfly, Birds

look alike
but not anatomically similar
though perform same function

* Different structures
evolving for same function
hence having similarity

② Eye of octopus, mammals

③ Flippers of Penguins, Dolphins

④ Sweet Potato (Root modification), Potato (Stem modification)
analogy.

* Similar habitats resulted in
Selection of similar adaptive features in different grps of organisms
but towards same function.

* In same line of argument, similarities in
protein performing, genes
gives rise to
common ancestory
given functions among diverse organisms

The biochemical similarities point to → same shared ancestory or structural similarities among diverse organisms

* Man has → bred selected plants / selected animals for → agriculture, horticulture, sport, security

has domesticated this → wild animals / crops

Intensive breeding programme has created → Breeds that differ from other breeds but still are of same grp. (eg - dogs)

* Argued - Man could create new breeds in 100s of yrs ? Nature could not do it in millions of yrs.

(3) Supporting Natural Selection Evolution

From - England

* In collection of moths made in 1850's (before industrialisation) it was observed

On trees : White winged moths >> Dark winged / Melanised moths

* After industrialisation in → 1920

On trees : Dark winged moths >> White winged moths.

↳ Proportion reversed

EXPLANATION :- "Predators will spot a moth against contrasting background."

* Post industrialised, tree trunks → dark due to industrial smoke soots

White winged moth did not survive to predators under this cond.

* Before industrialisation → thick growth of white a lichens covered trees trunks ← white winged moth hence survived

* Lichens — industrial pollution indicators

* Areas where industrialisation doesn't occur eg. RURAL AREAS → Melanic moths were low in no.

* This showed → in a mixed population those can better adapt survive → increase in population size

* NO VARIANT IS COMPLETELY WIPED OUT !!!

Excess use ① herbicides ② pesticides has resulted in selection of resistant varieties in much lesser time scale

TRUE FOR

"Microbes" against which we employ ① antibiotic ② Drugs against eukaryotic organisms / cell.

HENCE

Resistant organism/cell appearing in a time scale of → months → years (NOT centuries)

Eg. of → EVOLUTION DUE TO ANTHROPOGENIC ACTION

This also tells, EVOLUTION → not directed process in the sense of determinism

it is → STOCHASTIC PROCESS (based on → chance events in nature, → chance mutation in the organism.)

WHAT IS ADAPTIVE RADIATION

Darwin went to Galapagos Islands & he observed amazing diversity of creatures.

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On particular → Small Black birds (Later called as Darwin's Finches) → there were many varities of FINCHES in same island.

" Original Seed Eating features " ← from ← All varities he conjechured evolved on the Island itself.

Many other forms arose with ALTERED BEAKS enabling → Insectivorous / Vegetarian finches

ADAPTIVE RADIATION → Process of evolution of different species in a given geographical area

starting from a point → & literally radiating → to Other areas of geography (Habitat)

→ Perfect example — Darwins Finches

→ Another example — AUSTRALIAN MARSUPIALS

A no. of Marsupials ↓ each different from other ← evolved from ← Ancestral Stock ← but all within Australian Island continent

* When more than one (>1) adaptive Radiation ↓ appeared to have occured ↓ in an Isolated Geographical Area (representing different habitats) — called as CONVERGENT EVOLUTION

* (Placental mammals in Australia) → also exhibits ADAPTIVE RADIATION

Varities of such placental mammals ← in evolving into ← each of which → appears similar to a corresponding marsupial

(PLACENTAL WOLF → TASMANIAN WOLF MARSUPIAL)

* There is Convergent Evolution of → Australian Marsupials & Placental mammals

BIOLOGICAL EVOLUTION

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Evolution by → Natural Selection in → true sense → would have started when cellular forms of life with differences in metabolic capability originated on earth.

* Essence of Darwinian theory about Evolution → NATURAL SELECTION

* Rate of appearance of new life forms → is linked to → life cycle / life span

* Microbes that → divide fast → have → ability to multiply & → become → millions of individuals within hrs

Colony (A) (of Bacteria)
↓ growing on
given medium → change in medium would bring out → Colony / Population (B)
↓ has
built-in - variation
↓ in terms of
ability to utilise a Feed component.

Colony (B) that can survive under new condition
↓ during the course of time
This variant population
↓ outgrows
others & appear as → new species → This would happen → within Days

* For the same thing to happen in ① Fish ② Fowls → it would take → millions of years (as life span of these animals are in years)

* Here we say ∴ Fitness of B > A under new condition (better)

* Nature selects for → fitness is based on → characteristics which are inherited.

* Hence, there must be Genetic Basis for → selected & to evolve

* Some organisms are better adapted to survive in an otherwise hostile environment

* Adaptive ability is → inherited
  has → Genetic basis

* Fitness is → end result of → (1) ability to adapt & survive.
  (2) (get selected by nature)

* 2 key concepts of "Darwinian Theory of Evolution" → Branching descent
  → Natural selection

* Before Darwin → LAMARCK "French Naturalist"
  → said – Evolution of life forms had occured but driven by – [USE & DISUSE OF ORGANS]

Nobody believes this perfectly anymore

Eg – GIRAFFE → in attempt to forage leaves on tall trees
  ↓ had to adapt
  elongation of their necks
  → they passed on this acquired character of ~~elongated neck to succeeding~~ generations
  ↓
  Giraffe's ~~acquired long necks~~

* When we discuss "Story of this world" → we describe → evolution as a process

* Or, when we describe the "Story of life on Earth" → we describe → Evolution as a consequence of process – NATURAL SELECTION

Possible - WORK OF THOMAS MALTHUS influenced → Darwin
↓ on
Populations

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1) Natural selection is based on → certain observations which are → factual

Eg. Natural resources — are limited
Populations → stable in size except for → seasonal fluctuation

→ Members of population vary in → characteristics (infact no two individuals are like)
↓ even though they look superficially similar
↓ most of variation are inherited

→ Fact that, theoritically population size will grow exponentially if everybody reproduced maximally & fact that → Population sizes in reality are limited
means
There had been "COMPETITION FOR RESOURCES"

* Novelty & Brilliant insight of Darwin lie asserted → Variations, which are heritable
↓ which makes → resource utilisation better for few (adapted to habitat better)
will enable only those to → reproduce ← leave more progeny

* Hence, for a period of time → Over many generations
Survivors will leave more progeny → There would be → change in population characteristic ← New forms appear to arise.

MECHANISM OF EVOLUTION

Darwin → ignored Mendel's inheritable factors influencing phenotypes
* In 1st decade of 20th century, → Hugo De Vries based on work of Evening Primrose
brought forth idea of → Mutation → large differences → arising suddenly in → population

→ Believed - Mutations causes → Evolution
& not minor variations (heritable)
Darwin said

Mutations

* Random
* Directionless
* De Vries believed
  ↓
  Mutation
  ↓ caused
  speciation
  ↓ hence called
  SALTATION
  (single step large mutation)

Darwinian Variations

* Small
* Directional
* Evolution for Darwin
  ↓
  Gradual

HARDY-WEINBERG PRINCIPLE

In a given population → one can find out frequency of occurrence of alleles of a gene or a locus.

* Frequency is supposed to be remain fixed & even remain same throughout generations.

→ stated it using algebric equations.

* Principle Says — Allele frequency in a population are stable & is constant from generation to generation

OR

Gene pool (① total genes & ② their alleles in a population) remains constant.

GENETIC EQUILIBRIUM.

↓

Sum total of all the allelic frequencies is 1.

★ Individual frequencies → p, q

• In a diploid, p & q represent the frequency of alleles A & a

* Frequency of AA – p^2 [probability that an allele 'A' with a frequence 'p' appear on both the chromosomes of a diploid individual is simply product of probability, i.e p^2]

* Frequency of aa – q^2

* Frequency of Aa – $2pq$

$$p^2 + 2pq + q^2 = 1$$

* When frequency measured, differs from expected values

↓

The difference (direction) → indicates the extent of evolutionary change.

* Disturbance in genetic equilibrium, (Hardy Weinberg Equilibrium) change of frequency of alleles in a population, would then be interpreted as resulting in evolution.

5 factors affect Hardy Weinberg Equilibrium

Gene migration (Gene flow) | Genetic drift | Mutation | Genetic Recombination | Natural selection

1) **Gene Migration** — When migration of a section of ~~change~~ population to another → place → population, occurs, gene frequencies change in the → Original population → New population

↓

If gene migration happens, multiple times

↓

Gene flow

&

New genes/alleles are added to new population & these are lost from old population

2) **Genetic Drift** — If "gene migration" occurs by chance.

Original diffed population → Founders

Effect is → Founders Effect.

Sometimes, change in allele frequency is so different in new sample of population that they become Different species

Microbial Experiments show that → pre-existing advantageous mutations
↓ when
Observation of new phenotypes ← will results in ← Selected

Over few generations this would result in → SPECIATION

* **NATURAL SELECTION** → process in which heritable variations enabling better survival
↓ are enable
to reproduce & leave greater no. of progeny.

* A critical analysis, makes us believe that variation due to
  - mutation
  - Recombination (during gametogenesis)
  - Gene flow
  - genetic drift

results in → changed frequency of genes / alleles in future generation

* Natural Selection with → reproductive success → makes it looks like ↓ different population

can lead to

- **Stabilisation** → more individuals acquire mean character value
- **Directional change** → more individuals acquire value other than mean character value
- **Disruption** → more individuals acquire peripheral character value at both ends of the distribution curve.

A BRIEF ACCOUNT OF EVOLUTION

* About 2000 mya (million years ago) → 1st cellular forms of life appeared on earth.

* Mechanism of how non-cellular aggregates of Giant macromolecules, could evolve into cells with membranous envelop is → not known.

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* Some of these cells had ability → to release O_2 ↑.

* The skn could have been → similar to the light-reaction in photosynthesis (where water is split with help of solar energy captured & channelised by appropriate light harvesting pigments.

* Slowly, Single celled organisms became → multicellular life forms.

* By 500 mya → Invertebrates were formed & active

* By 350 mya → Jawless fishes evolved

* Around 320 mya → Sea weeds, Few plants } existed

* First organisms, that invaded Land — Plants

They were widespread on land when animals invaded land.

* Around 350 mya → Fish with stout & strong fins could move on land & go back to water.

* In {1938} → Fish caught in South Africa was a Coelocanth (which was thought to be extinct)

Coelocanth → LOBEFINS → evolved into → FIRST AMPHIBIANS (lived on both land & water)

Coelocanth → No specimens left today

FIRST AMPHIBIANS → Ancestors of modern day frog, Salamanders

* Amphibians → evolved into → Reptiles → lay → thick shelled eggs (did not dry up in sun like that of amphibians)

↳ We only see modern day descendants → Turtles, Tortoise, Crocodiles

* Next 200 million years or so — Reptiles of different → shapes, size dominated on earth.

* Giant ferns (Pteridophytes) → were → present but they all fell to form coal deposits slowly

* Probably 200 million years ago (mya) → Some of land reptiles went back into water to evolve into fish like reptiles (Ichthyosaurs)

* Land Reptiles → were → Dinosaurs

Biggest of them — TYRANNOSAURUS REX
- 20 feet in height
- huge daggersome teeth

65 mya
Dinosaurs suddenly disappeared from earth
1. climatic change may have killed them
2. Most of them evolved into Birds

→ Real reasons are not known → Truth may lie in between

* Small sized Reptiles of that era → still exist today

* First mammals → were like → Shrews → their fossils were small sized

* Mammals → were
- Viviparous → protected the unborn young inside mothers body
- intelligent in sensing & avoiding → danger at least
- took over when Reptiles came down.

* South American Mammals — resembling → Horse, hippopotamuses, Bear, Rabit

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* Due to Continental Drift → pouched mammals of Australia survived
  bcz of ← lack of competition from others mammals

* Mammals who live wholly in water → whales, Dolphins, Seals, Sea cows

* Most successful story — Evolution of Man with
  - language skills
  - self-Consciousness

ORIGIN & EVOLUTION OF MAN

⊛ About 15 mya, primates → DRYOPITHECUS, RAMPITHECUS } → were existing
  they were → hairy; walked like → gorillas, chimpanzee

⊛ RAMAPITHECUS - More man-like
⊛ DRYOPITHECUS - More ape-like

⊛ Few fossils of man-like bones } have been → discovered in → Ethiopia, Tanzania
  → this revealed Hominid features leading to belief
  → (3-4 mya, man-like primates walked in EASTERN AFRICA.)
  → not taller than 4 feet
  Walked upright

---

* 2 mya → AUSTRALOPITHECINES → lived in East African Grasslands
  - hunted with the stone weapons
  - essentially, ate fruits

---

* Some of the bones, among bones discovered were different
  - This creature was ← Ist human like being ← Hominid
  - HOMO HABILIS
    - Brain capacities — 650 - 800 cc
    - did not eat meat

---

* Fossils discovered in 1891 (Java)
  - revealed next stage — HOMO ERECTUS
    - ate meat
    - appeared around 1.5 mya
    - Brain capacities → 900 cc

- NEANDERTHAL MAN
  - Brain size - 1400 cc
  - Lived near → east, central → Asia
  - b/w 1,00,000 – 40,000 yrs back
  - used hides to protect their body
  - buried dead

- HOMO SAPIENS
  - rose in Africa
  - moved across continents & developed into races

- MODERN HOMO SAPIENS → Rose in - Ice age (b/w 75,000 - 10,000 yrs ago)

* Pre historic cave art developed in → 18000 yrs ago
* One such Cave Art / painting seen at → Bhimbedka Rock Shelter in Madhya Pradesh, Raisen district.

* Agriculture came → 10,000 yrs back.
  ↳ human settlements started

* Rest of what happened → is part of human history of Growth & decline of Civilisation

* Origin of life on Earth → can be understood only against the → Background of origin of Universe (especially earth)

* Darwinian ideas were of → organic evolution by natural selection

* Variations in population → results in → Variable fitness

* ① Habitat Fragmentation ② Genetic Drift → may → accentuate these variation → leading to appearance of new species → hence EVOLUTION

* Homology → is accounted for → by the idea of Branching descent.

* Study of comparitive → anatomy, fossils, Biochemistry → provides evidence for → evolution

* Story of Evolution of Modern Man → appears to be → Parallel evolution of human brain & language.

Q. Can we call human evolution as adaptive Radiation?
No.

Q. List 10 modern day animals & using the interest resources link it to a corresponding ancient fossil. Name both.

Horse – Eohippus
Man – Ramapithecus
Whale – Protocetus
Elephant – Moerithers
Dog – Leptocyon
Camel – Protylopus
Tetrapods – Ichyospega
Bat – Archaeonycteris

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Taxonomic Hierarchy Of Horse

S - E. ferus
G - Equus
F - Equidae
O - Perissodactyla
C - Mammalia
P - Chordata
K - Animalia

Evolutionary stages of Horse

Eng. Eohippus 4 toes

↓

Me Mesohippus 3 toes

↓

Merry Merychippus 3 toes

↓

Pilo Pilohippus 1 toe

↓

Equus. Equus. No toes

Evolution of horse has caused some toes on the horse leg to shorten ultimately disappeared.